

EFFICACY OF METHYL IODIDE AND SYNERGY WITH CHLOROPICRIN FOR CONTROL OF SOIL-BORNE FUNGI

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Soil fumigation has been used for more than five decades to control soil borne crop pests including plant pathogenic fungi, plant parasitic nematodes, and weeds. Methyl bromide (MB) is one of the most widely used and effective fumigants because of the broad-spectrum of pests it controls. However, the Montreal Protocol, an international treaty responsible for limiting the use of ozone depleting compounds, stipulates that MB use must be phased-out in developed countries by 2005 and in developing countries by 2010. Research is currently underway to develop alternative crop protection practices to replace MB soil fumigation.

Methyl iodide (MI) has been suggested as an alternative fumigant to replace MB. At equal molar rates, MI is more effective than MB at controlling plant pathogenic fungi, weeds, and plant parasitic nematodes. Unlike MB, the ozone depleting potential of MI is low because the molecule is broken down by photolysis in the troposphere. Therefore, MI does not have the same environmental concerns that have limited the use of MB.

The objectives of this research were, therefore, to compare the dose-response of various soil-borne fungi to MB and MI and to determine if MI-chloropicrin combinations interact synergistically to control plant pathogenic fungi.

Materials and Methods

Fusarium oxysporum, *Phytophthora citricola*, *Phytophthora citrophthora*, *Pythium ultimum*, *Rhizoctonia solani*, and *Verticillium dahliae* were grown on autoclaved pearl millet seed (*Pennisetum glaucum* L.) supplemented with 1/4 strength clarified V-8 broth (75 cm³ millet seed:200 ml broth) for seven days. The fungal cultures were dried for three days before incorporation into potting soil (5 cm³ millet seed: 45 cm³ soil). The soil consisted of a 1:1 (v/v) mix of fir sawdust and top soil (85% sand, 11% silt, 4% clay, 9.6% organic, pH 6.2) brought to 14% moisture (wt/wt) and autoclaved twice over consecutive days before use. Each infested soil sample was placed in a cone-shaped, paper coffee filter. The open end of each filter was stapled closed prior to fumigation.

MB or MI was pipetted into gas-tight fumigation chambers (1.9 dm³ vol.) containing individual infested soil samples at either 0.0, 3.1, 6.3, 12.5, 25, 50, 75, 100, 200, 400, or 800 µM. Calculations of fumigant molar concentrations were based on the volume of the fumigation chamber. Samples were fumigated for 48 hr while maintained at room temperature (23°C). After fumigation, samples were vented under a fume hood for 12 hours. Sixteen millet seeds from each soil sample were plated on either selective medium or potato dextrose agar. The plates were

incubated at 23°C and the seeds were assessed with the aid of a dissecting microscope for fungal growth 24 and 48 hr after plating.

In the synergism experiment, *F. oxysporum* infested soil samples were prepared as described above and fumigated with either MB or MI alone, MB or MI combined with chloropicrin, or fumigated with only chloropicrin. The same concentrations of MB and MI as in the dose-response experiment were used excluding 800 µM. Chloropicrin concentrations used were 0.0, 0.63, 1.3, 2.6, 5.1, 10.2, 15.4, 20.5, 41.0, and 82.0 µM. Chloropicrin concentrations corresponded to 17% of the total molar concentration of MB and MI with chloropicrin. Samples were fumigated as described above.

Results & Discussion

The fungal species tested varied in their sensitivity to each soil fumigant. In general, MI was a more effective than MB when compared on a molar basis. *P. ultimum* was the most sensitive fungal species tested with an EC_{50} for MB and MI of 15.5 and 8.6 µM, respectively. *R. solani* was the least sensitive organism with an EC_{50} for MB and MI of 253.4 and 161.4 µM, respectively. The oomycetes, *P. ultimum*, *P. citricola*, and *P. citrophthora*, were among the most sensitive species to the fumigants.

The relative potency of MI compared to MB varied over the fungal species tested. Relative potency ([MB]:[MI]) values ranged from a high of 5.2 for *P. citricola* to 1.5 for *F. oxysporum*. Averaged over all fungal species tested, MI was 2.7 more efficacious than MB.

Using a previously developed method to detect synergism, the additive value for *E* (expected mortality as a percent of control) was 2.8 and 4.4 times less than the 50% value obtained when MB and MI were applied in combination with chloropicrin, respectively. The percent mortality for the additive model for both MB and MI was significantly less than the 50% mortality obtained when the fumigants were applied in combination. This significant difference indicates a synergistic response.

Differences in the predicted and actual dose-response curves for *F. oxysporum* fumigated with combinations of chloropicrin, MB, and MI indicates a synergistic interaction. The EC_{50} for the actual MB-chloropicrin dose-response curve was 2.2 times less than the predicted curve for the additive model. Combining MB and chloropicrin increased the potency 9.6 times compared to MB alone. The EC_{50} for the actual MI-chloropicrin dose-response curve was 2.8 times less than the value predicted from the additive model. Combining MI with chloropicrin increased the potency 7.3 times compared to MI alone. With both MB and MI, the EC_{50} for the actual dose-response curves was significantly lower than the EC_{50} for the predicted additive curves.

Currently, MI is not a registered pesticide. Although the pesticidal activity of MI has been shown to be generally much greater than MB, further interest in registering the compound is necessary before MI can become a tool for agricultural use. MI is a promising compound that could be used alone or in combination with chloropicrin to control crop pests at the level growers have become accustomed to with MB for the past 50 years.